RESEARCH DEPARTMENT

TELEVISION CO-CHANNEL INTERFERENCE AT VERY LOW OFFSETS

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THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

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SUMMARY

The subjective appearance of the patterns that are produced when a television transmission suffers co-channel interference at very low offsets is described, and the protection ratio required at these offsets is discussed. In the case of non-offset working, an assessment is made of the improvement of the frequency stability of each of the two vision carriers required to give a worth-while reduction of protection ratio, relative to that at present specified for carrier stabilities of ± 500 c/s. The experiments were conducted on the 405-line standard, but the conclusions are believed to apply to all standards which use fifty fields per second.

1. INTRODUCTION

It is well known that the subjective effects of interference between two television emissions in the same channel can be reduced by appropriately choosing the "offset", or difference between the carrier frequencies, in relation to the line-scan frequency. This is because the curve relating protection ratio* and offset exhibits periodicities in terms of the line- and field-scan frequencies.[1,2,3] The offsets most commonly used are one-third, two-thirds, four-thirds, etc., of the line-scan frequency; their use enables three transmitters to be allotted frequencies in a favourable relationship. For example, three transmitters may have carrier frequencies $F - 2/3F_L$, F, and $F + 2/3F_L$ where F_L is the line-scan frequency and F is the nominal vision carrier frequency for the shared channel. For 405-line emissions the protection ratio is 34 dB. When additional transmitting stations prove necessary it is usual to allocate to each of these one of the above three frequencies. There will then be pairs of stations having a nominal offset of zero, and for interference between these the protection ratio is 44 dB.** It has been suggested that this protection ratio can be reduced substantially if the carrier frequencies are suitably adjusted and controlled with sufficient precision. This report describes an investigation of this proposal.

During an earlier investigation of the effect of co-channel interference on television transmissions of different standards[1] it was assumed that the offset might remain constant to within ± 1 c/s for significant periods of time, and the measurements were therefore made with offsets capable of being defined to this

*The minimum acceptable ratio of the amplitude of the wanted signal to that of the interfering signal.

**This value is obtained from the experimental result shown in Reference 1. The formalized curves of Reference 4, however, indicate a protection ratio of 45 dB.

accuracy. The long-term frequency stability of a transmitter was, however, assumed[4] to be no better than ± 500 c/s. For this reason, no measurements were then made with very low offsets. Moreover, the protection ratio specified for any given offset was in fact the greatest protection ratio required for a range of offsets within ± 25 c/s of the nominal value: the curve, shown in Fig. 1, relating offset and protection ratio is therefore the upper boundary of the envelope containing the periodicity occurring at the field-scan frequency.

The protection ratio required for a nominal offset of zero is taken to be the highest value required within the range of offsets determined by the frequency stability of the two carriers: if both carriers have stabilities of ± 500 c/s offsets up to 1000 c/s must be included. This approach, applied to the protection-ratio curve shown in Fig. 1, leads to the protection ratio of 44 dB quoted above.

In order to determine the reduction in protection ratio that could be achieved by stricter control of frequency, detailed measurements of protection ratios were made at very low offsets. The investigation was confined to 405-line wanted and interfering signals. These carried different programmes, the two field frequencies being separately locked to the same mains frequency. The experimental conditions were the same as those in the principal investigation described in Reference 1. The receiver was provided with a picture tube having a 21 in (53 cm) diagonal and the observers were distant from it between four and six times the picture height. The peak brightness of the picture was 15 ft-L (160 asb) with an ambient illumination, measured on the screen of the display tube, of about one-half foot lambert (5 asb). The amplitude of the wanted signal was adjusted to produce a "fringe-area" signal-to-noise ratio in the displayed picture, the ratio of the d.a.p. composite video signal voltage to the r.m.s. noise voltage being 27 dB.

2. DISCUSSION OF RESULTS

During the earlier investigation it was found that for offsets less than one-half of the line-scan frequency the pattern was most visible when the offset differed from a harmonic of the field-scan frequency by a few cycles per second. Under these conditions the pattern consisted of a set of dark and light horizontal stripes moving slowly up or down the picture. The greatest protection ratio was required at an offset near to the twelfth harmonic of the field-scan frequency (600 c/s). At this frequency about ten pairs of dark and light stripes are visible. Slowly moving patterns, having a coarser structure than this, were found to be less visible and required a smaller protection ratio: this result is in agreement with those obtained by Schade.[5]

Fig. 2 shows the relation between offset and protection ratio obtained for offsets between 3 and 50 c/s. At very low offsets, the interference takes the form of a brightness flicker of the picture as a whole; the maximum in the curve occurring at an offset near to 10 c/s is associated with the enhanced sensitivity of the eye to flicker occurring at this frequency.[6,7] The highest flicker frequency that can occur is 25 c/s, when the brightness of successive fields of the display is alternately increased and diminished; for offsets higher than this the strobing effect of the scanning process causes the interference to take the form of one broad horizontal stripe. The speed of movement of this stripe up or down the picture depends on the

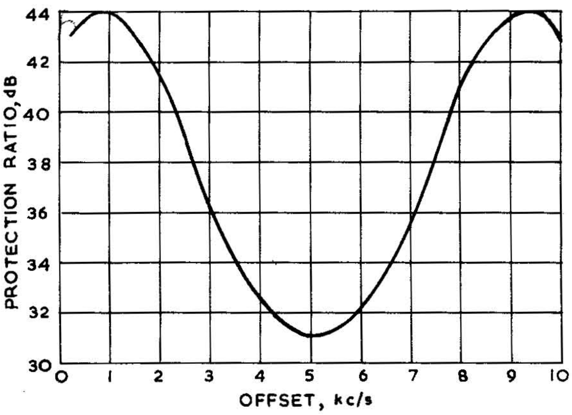

Fig. 1 - Protection ratio required for 405-line wanted and interfering signals for offsets between 200 c/s and 9·9 kc/s, under conditions specified in the text

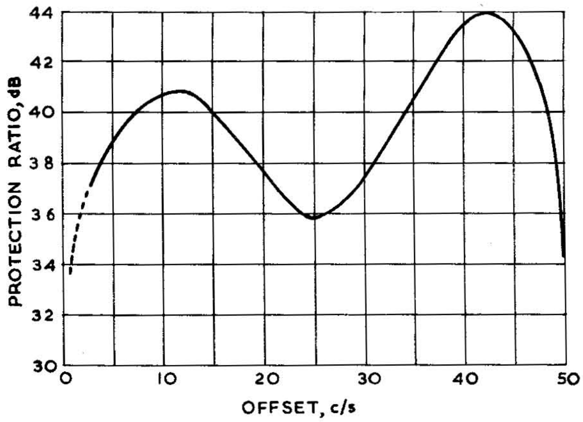

Fig. 2 - Protection ratio required for 405-line wanted and interfering signals for offsets between 1 c/s and 50 c/s

difference between the offset and the field-scan frequency. It was found that while a slowly moving stripe required a relatively low protection ratio, as would be expected by extrapolating the curve in Fig. 1, a much higher protection ratio was required when the speed of movement of the pattern was increased. The condition of maximum visibility occurred when the offset differed from the field-scan frequency by about 8 c/s; in this case the interference took the form of a brightness flicker very similar to the effect produced by an offset of 10 c/s. The protection ratio required for this offset was found to be equal to the maximum value shown in Fig. 1.

As the offset was increased so as to be near successively higher harmonics of the field-scan frequency, the pattern of slowly moving stripes progressively replaced the flickering effect as the condition of maximum visibility. The visibility of these two types of interference relative to one another was to a large extent influenced by the nature of the displayed picture; in addition, the protection ratios required differed from observer to observer. Comments from the observers taking part in the tests indicated that in some cases the flickering effects produced a sensation of mental discomfort which was not present when the interference took the form of slowly moving stripes. With these observers the flicker had to be reduced to a very low level before the display could be viewed for prolonged periods of time.

At an offset within ± 25 c/s of 200 c/s, about 1 dB less protection ratio was needed than at offsets near to 600 c/s, but at offsets lower than 200 c/s, the appearance of the flickering effect prevented any further decrease in the protection ratio; in fact, the protection ratio required near to 50 c/s was equal to that required near 600 c/s. In all these measurements the standard deviation of the results was about ± 3 dB.

At an offset equal to the line-scan frequency the interference pattern consists of one vertical stripe, while at an offset differing from the line-scan frequency by the field-scan frequency the pattern takes the form of one diagonal

stripe. The rapid movement of either of these stripes across the picture gives rise to flickering effects similar to that described for an offset near to the field-scan frequency. As the difference between the offset and the line-scan frequency is increased the flickering effects are replaced by patterns of horizontal stripes, as in the case of very low offsets, and the same protection ratio is therefore required for offsets within 600 c/s of the line-scan frequency as is required for offsets below 600 c/s.

It can be seen from Fig. 2 that if the offset varies by less than ± 35 c/s about zero the required protection ratio is 3 dB below the maximum value; an additional reduction of 3 dB may be achieved by employing an offset centred on 25 c/s with a variation from this value of less than ± 6 c/s. A further 3 dB reduction of the protection ratio may only be obtained if the variation of the offset is less than about ± 1·5 c/s, the nominal offset being zero in this case: this value is only approximate because of the experimental difficulty in obtaining a stable offset lower than 3 c/s.

At offsets below about 4 kc/s the shape of the protection ratio curve is independent of the line standard of the wanted television signal; the results obtained at very low offsets for a 405-line wanted signal are therefore general and apply to all wanted displays having a field-scan frequency of 50 c/s. This implies that in the case of a 625-line wanted signal, the protection ratio required for an offset near to 50 c/s is some 15 dB greater than that required for an offset near to one-third of the line-scan frequency. This disagrees with the result obtained by Hopf,[3] who equates the protection ratios required at these two offsets.

The value of protection ratio of 38·5 dB obtained at a frequency of 5 c/s is also in disagreement by some 4·5 dB with the value obtained by the Post Office Research Station.[8] In the latter experiments the same picture was used for both the wanted and the interfering signals, the interfering modulation being delayed by 13 microseconds relative to the wanted modulation. The use of this form of interference, which is likely to cause less subjective annoyance than the case in which two picture sources, separately locked to the same mains frequency, are used for the two signals, probably accounts for the difference in the protection ratios obtained in the two cases.

3. CONCLUSIONS

The protection ratio appropriate to an offset that is very small or zero depends upon the accuracy with which the carrier frequencies can be maintained. The protection ratio appropriate to any particular case can be deduced from Fig.2. In broad outline the practical conclusions are as follows:

There is little or nothing to be gained by improving the frequency stability of transmitters unless the tolerance for each transmitter can be reduced from the present value of ± 500 c/s to ± 17·5 c/s. In this case the nominal offset should be zero, so that the actual offset will remain less than 35 c/s. The protection ratio is then reduced from 44 dB to 41 dB.

There is little or nothing to be gained by reducing the tolerance for each transmitter below ± 17·5 c/s unless it can be reduced to ± 3 c/s. In this case a nominal offset of 25 c/s should be employed so as to obtain an actual offset of 25 ± 6 c/s. The protection ratio is then reduced to 38 dB.

For a further useful reduction in protection ratio it would be necessary to revert to a nominal offset of zero and to achieve a tolerance of the order of ± 0·75 c/s for the frequency of each transmitter. Further work would be required to investigate such small offsets precisely. It would also be necessary to consider the phase stability of the propagation path.

Any variations in field frequency resulting from locking to the supply mains will not affect the conclusions stated above. No steps need be taken to make the offset vary with the field frequency.

4. REFERENCES

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